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CALCULATION OF COKING CHARGES ON THE BASIS OF PETROGRAPHIC CHARACTERISTICS OF COALS

I.L.Ammosov, I.V.Eremin, S.I.Sukhenko and L.S. Oshurkova
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There is no method available at present in the coking industry for calculating coal charges for producing coke with predetermined physico-mechanical characteristics.

Side by side with this, the coal classification based on the yield of volatile and the thickness of the plastic layer does not reflect their coking characteristics and does not permit to use them more extensively and correctly for coke making. It is well known that the yield of volatiles in most cases does not reflect the true metamorphism of the coals. The difference among them would be more pronounced the more nonuniform is their petrographic composition, the greater is the ash content, and the higher is the state of coal oxidation. Only in coals containing more than 80% vitrinite and but little leiptinite, which are found at the middle stages of metamorphism, there is no difference between the yield of volatiles and the true metamorphism. As far as the thickness of the plastic layer is concerned, the plastometric method is not sufficiently objective, while in application to more metamorphosized coals it is not sensitive. In coals of the SS, and partially of K_2, types, found in the IV_3- V_1 stages of metamorphism and containing well caking vitrinite, it is not possible to determine by the plastometric method the thickness of the plastic layer. In these cases the coal is characterized by $y = 0$ mm.

It has been established that the composition and properties of coals depend on many factors, such as original material, conditions of accumulation, chemical character and water content of the surroundings, degree of metamorphism, etc. A most complete characteristic of coals can be obtained by supplementing the conventional characteristics with the results of their study by means of new coal petrography methods.

Coals, and particularly Kuznetsk basin coals, vary widely in their petrographic characteristics. Each seam can be considered here as a natural charge. The relation of "fusible" components, of the group of vitrinite and leiptinite, and "infusible" (leaning) of the group of fusinite and the major portion of the components of the semi-vitrinite group,varies in the Kuznetsk basin widely. (The fusibility of the vitrinite and leiptinite groups components varies with the stage of metamorphism of the coal). Thus the content of the leaning components varies in the range of 5 to 65% and of "fusible" ones between 95 and 35%. Depending on the stage of metamorphism, these variations of the proportions have a different effect on caking.

Besides metamorphism, the "fusibility" of the vitrinite group components is affected by their degree of reduction and oxidation.

Before offering a new principle of charge formulation, the petrology laboratory of the Institute of Mineral Fuels of the Academy has investigated during 1952-1954 all major seams of all mines of the Kuznetsk basin. In this work much attention was given to the petrography of coal. As the theoretical basis for the application of the new method served investigations in which were examined basic causes determining different properties of coals. (1)

The stage of metamorphism was determined by the reflectivity. Calculation of the "fusible" components $\sum FC$ and "lean" ones $\sum LC$ present in coal was made in accordance with the decisions of the all-Russian conference of coal petrographers. In this connection, as "fusible" components were considered components of the vitrinite group $\underline{Vt}$, of leiptinite $\underline{L}$ and 1/3 of the components of the semi-vitrinite group Sv. As leaning components are grouped together fusinite group components F and 2/3 of those of the semi-vitrinite group Sv. Here $\sum FC + \sum LC = 100\%$ of the organic part of the coal. In Table 1 are shown the stages of metamorphism of coals according to I. Annosov.

Table 1. Stages of coal metamorphism.

Approximate kind and group of coal	Metamorphism stage	Indices of subdivisions of metamorphism stages in sub-groups
Brown	zero	0_1 0_2 0_3
Long flame (cannel)	first	I_1 I_2 I_3
Gas coal	second	II_1 II_2 II_3
Bituminous	third	III_1 III_2 III_3
Coking	fourth	IV_1 IV_2 IV_3
Lean coking	fifth	V_1 V_2 V_3
Lean	sixth	VI_1 VI_2 VI_3
Lean highly metamorphosized	seventh	VII_1 VII_2 VII_3
Anthracite	eighth	$VIII_1$ $VIII_2$ $VIII_3$

On the basis of the degree of metamorphism and petrographic composition new characteristics have been established - index of leanness and coking coefficient.

Index of leanness is the relation between the leaning components present in the charge $\sum LC$ and the amount of leaning components $\sum LC'$ required for a given charge in order to achieve the optimum relation between fusible and leaning components.

The leaning components both improve and deteriorate coke quality depending on how much of them are added to the coking coal, which is the stage of metamorphism of this coal, and what are the operating conditions. It is evident that one must know the amount of leaning components to be introduced into the charge for the best quality of metallurgical coke.

$\sum LC^1$ is determined by the formula

$$\sum LC^1 = \frac{\sum FC_1}{a_1} + \frac{\sum FC_2}{a_2} + \dots + \frac{\sum FC_n}{a_n}$$

where $\sum FC_1$ $\sum FC_2$ $\sum FC_n$ is the sum of "fusible" components of the coals of the charge of given stages of metamorphism; $a_1, a_2 \dots a_n$ optimum relation between "fusible" and leaning components for corresponding degrees of metamorphism (the optimum relations are determined experimentally). For coals having the stage of metamorphism of III_1-III_3, for example, for each per cent of leaning components are required 2 per cent of "fusible" components, for IV_1-IV_2 are needed 6%, etc. This is shown in the diagram of Figure 1.

Coking coefficient which characterizes "fusible" components is determined by the formula

$$K = \frac{\sum FC_1 \times K_1 + \sum FC_2 \times K_2 \dots + \sum FC_n \times K_n}{\sum_1^n FC}$$

where K_1, $K_2 \ldots K_n$ are coefficients of coking of the corresponding stages of metamorphism with a given content of the leaning components in the charge. They are graphically presented in the diagram of Figure 2.

Tumbler residue is determined by the index of leanness and coking coefficient on the classification diagram for multicomponent coking charges, Figure 3.

As an example can be given the calculation of the production charge of the Kuznetsk works, Table 2.

Table 2. Production charge of the Kuznetsk metallurgical works from 8/1/'56 to 8/8/'56.

Mine	Components of the coal charge % Type	Metamorphism		Fusinite Content	Σ LC	Σ FC	a	K
Kapitalnaya 1 Kapitalnaya 2	Zhl	III_1 - III_3	25	8	2.0	23.0	2.0	5.46
Koksovaya 2	K	IV_1 - IV_2	10	30	3.0	7.0	6.0	6.42
Stalinskaya	K	IV_1 - IV_2	12	34	4.1	7.9	6.0	6.42
Vakhrusheva No.3	K_1	IV_1 - IV_2	13	17	4.8	8.2	6.0	6.42
Stalinskaya No.3	K_2	IV_3 - V_1	13	42	5.6	7.4	16.0	6.0
Zyryanovskaya	PZh-G	II_2 - II_3	7	8	0.6	6.4	2.5	4.40
Voroshilova	SS	IV_1	12	51	6.1	5.9	4.4	6.42
Tom Usinskaya No.1,2	KZH2	III_3	8	43	3.4	4.6	2.5	5.70

$$\Sigma\, LC^1 = \frac{23.0}{2.0} + \frac{7.0}{6.0} + \frac{7.9}{6.0} + \frac{8.2}{6.0} + \frac{7.4}{16.0} + \frac{6.4}{2.5} + \frac{5.9}{4.4} + \frac{4.6}{2.5} = 21.6$$

$$K = \frac{23.0 \times 5.46 + 7.0 \times 6.42 + 7.9 \times 6.42 + 8.2 \times 6.42 + 7.4 \times 6.00 + 6.4 \times 4.4 + 5.9 \times 6.42 + 4.6 \times 5.7}{70.4} = 5.83$$

According to the parameters given in the classification diagram, the tumbler residue should be 327 kilograms. The production results gave for the tumbler residue 327 kilograms.

Many calculations made at IGI (2) as well as the calculations of the coke laboratory of the Kuznetsk Metallurgical Works (3) have established that the difference between the calculated and the production test results in the majority of cases lies between 4 and 5 kilograms. There are reasons to believe that under conditions of a constant method of preparation of the multicomponent charges and a constant coking practice this difference will be reduced.

How well the calculated index of the tumbler residue agrees with the actual one shows the correlation coefficient calculated on the basis of 44 tumbler prognoses as related to experimental coking of different charges containing 7.41-9.08% ash. It happened to be 0.827. The accuracy of determination of the coefficient of correlation can be increased by additional experiments.

In compounding charges the following points should be considered: (1) better caking can be obtained on coking charges composed of coals close to each other in respect to their degree of metamorphism and (2) the maximum fissuring is produced when there is a considerable difference among the stage of metamorphism of the charge components. On this account, one should not introduce into a charge having a high concentration of gas coals having the metamorphism stage of II_1-II_2 a large proportion of SS coals, the stage of metamorphism of which ranges between IV_1 and Vl_1, or vice versa.

On the basis of many experiments, two types of charges are recommended:

1. from coals having the metamorphism stage of II_2 to IV_2
2. from coals having the metamorphism stage of III_1 to V_1

It has been established that Charge 1 containing an appreciable amount, more than 20%, of coals with metamorphism stage of II_2 - II_3 can take not more than 30% of leaning components; any further increase of the latter sharply affects coke quality. Charge 2 can take 33% of leaning components. It has been also established that, with the present coking practice, the influence of the leaning components on the quality of coke made of coals having metamorphosis stage of from II_3 to V_1 is about the same. Differences in the behavior of leaning components of coals having different stages of metamorphosis are, apparently, slight and are therefore but little noted during coking.

Conclusions:

1. The proposed method can be used for compounding multicomponent coking charges with up to 25% gas coals containing fusain. For a more precise compounding of charges involving spores gas coals, as well as of charges composed of but a few components, additional investigations are in order.

2. Petrographic analysis can be employed for the current control of coals used for coking. It appears more reliable than the other existing methods, particularly for coals made of a mixture of coals from different seams and for coals with an advanced stage of metamorphosis having the plastic layer greater than 7 mm.

Bibliography

1. I.I. Ammosov. Basic reasons of different composition and properties of coals. Trudy Pervago Vsesoyuznago Soveshchaniya po Khimii i Genezisu uglei. 1950.

2. I.I. Ammosov, I.V. Eremin and B.G. Babashkin. Utilization of petrographic characteristics of coals for compounding coking charges. IGI, Akad. Nauk, U.S.S.R., 1954.

3. Anon. Combined report of IGI and the Coke Laboratory of the Kuznetsk Metallurgical Works. Rational compounding of coals on the basis of their petrographic properties. IGI, Akad. Nauk U.S.S.R., 1955.

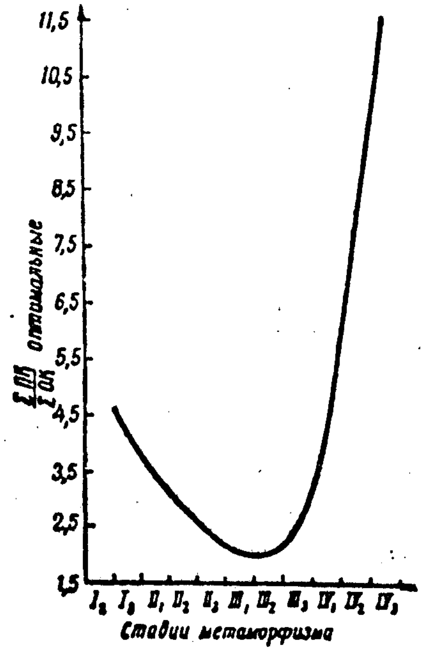

Figure 1. Optimum relation between "fusible" and leaning components of coals having different degree of metamorphism
Abscissae: Stages of metamorphism
Ordinates: Optimum Σ FC/ Σ LC

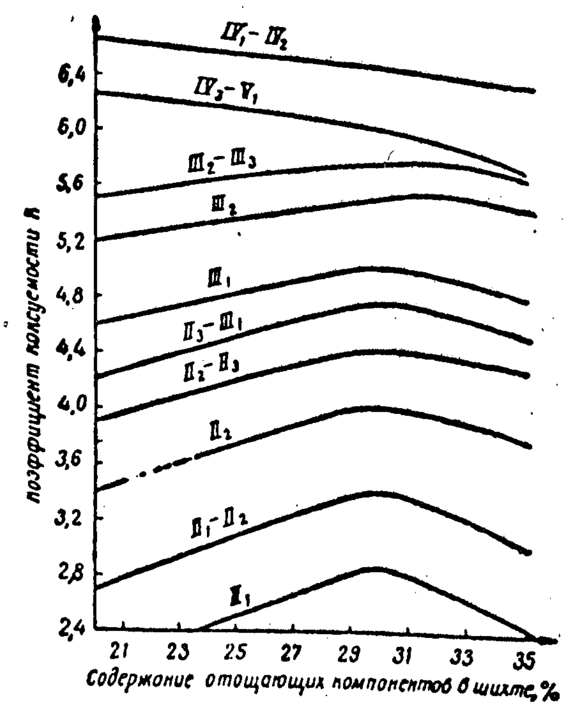

Figure 2. Dependence of the coking coefficient on the stage of metamorphism and the concentration of the leaning components in the charge.
Abscissae: Concentration of leaning components in charge
Ordinates: Coking coefficient

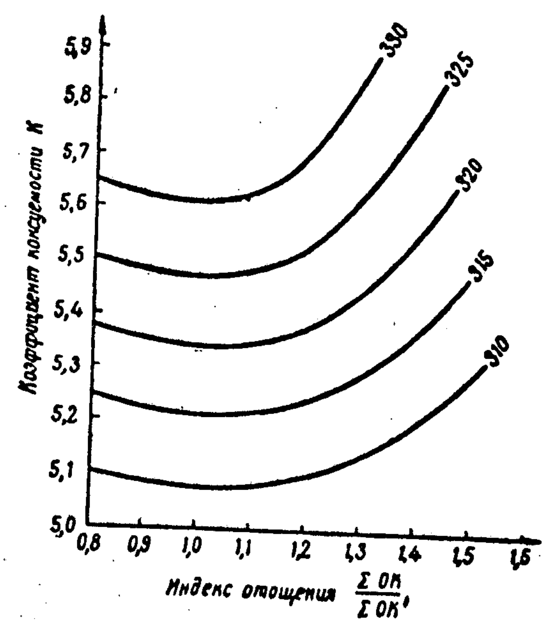

Figure 3. Classification of coking charges for Kuznetsk and Chelyalinsk plants. Curves present identical residues in a standard tumbler.
Abscissae: Index of leaning Σ LC/ Σ LC[1]
Ordinates: Coking coefficient K